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(54) Rotary cutting tool with indexable insert

Drehendes Schneidwerkzeug mit Wendeschneideinsatz

Outil de coupe rotatif avec plaquette de coupe indexable

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(56) References cited:
EP-A- 0 207 914
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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an indexable type rotary cutting tool.

2. Description of the Related Art

[0002] An indexable type rotary cutting tool according to the preambles of claims 1 and 2 is known, for example, from EP-A-0 207 914.

[0003] Conventionally, there have been dominantly used indexable type rotary cutting tools using indexable inserts each designed in a triangular shape, a rectangular shape, a rhombus shape or the like. In these tools, the main cutting edge is of a straight cutting edge type. A feed per one tooth as a general cutting condition is equal to 0.1 to 0.5 mm/tooth for casting-cutting and 0.1 to 0.3 mm/tooth for steel-cutting although it is varied according to depth and width of cut. However, such examples begin to appear that the use of an indexable type rotary cutting tool using a button insert implements the working at a feed which is not less than about two times as large as a straight cutting edge, thereby resulting in enhancement of the working efficiency. This indexable type rotary cutting tool uses button positive type inserts including various sizes of 8 to 20 mmϕ. The clamping mechanisms therefor are broadly classified into two kinds, one kind being designed to fix the insert by pieces of a wedge and a supporter, and the other being designed to fix the insert by a fastening screw inserted into a pin hole disposed at the center of the insert.

[0004] Further, the button insert is slightly large in cutting resistance because of its shape-dependent characteristic, but longer in length of the cutting edge than the straight cutting edge, and further high in insert strength; thereby providing many advantages of making it possible to cut a high hardness material, and then lengthening the lifetime of the insert, etc. As an example using such a button insert is proposed tools as described in Japanese Laid-open Patent Application (Kokai) Nos. 9-225724 and 10-118901.

[0005] However, in recent high efficiency working (contour line working), such cases begin to appear that chattering-vibration is caused during a process of cutting the corner portions and the grooves, thereby finally causing the inserts to be damaged.

SUMMARY OF THE INVENTION

[0006] It is therefore an object of the present invention to suppress the chattering-vibration during the cutting process of the corner portions and the grooves to thereby realize a stable and high efficiency working (contour line working).

[0007] In order to attain the above object, according to a first aspect of the present invention, there is provided the indexable type rotary cutting tool defined in in claim 1.

[0008] Further, according to another aspect of the present invention, there is provided the indexable type rotary cutting tool defined in claim 2.

[0009] According to the invention, the substantial length of the cutting edge during a cutting process is substantially constant, thereby resulting in a smooth facing and engraving, which provides a high efficient working. This results in enhancement of the efficiency of the contour line working.

[0010] In the indexable type rotary cutting tool according to the present invention, a bottom edge serve as a main cutting edge. The main cutting edge ranges from 3 to 35 degrees in cutting edge angle, and is rounded in a radius-round shape. This tool carries out cutting only at a rounded portion in the neighborhood of the tip thereof and hence is shorter in the length of the cutting edge than the conventional button insert. This shortens a substantial length of the cutting edge contacting to the material to be cut in the cutting process for the corner portions and the grooves which are small in the draft of the mold and large in cutting stock, thereby preventing occurrence of the chattering-vibration and thus implementing a stable use of the tool without trouble. The smaller the cutting edge angle of the main cutting edge is, the more smooth the cut face is. If the cutting edge angle is less than 3 degrees, the axial direction-wise depth of cut is reduced, resulting in degradation of the efficiency and obstruction to the practical use. On the other hand, if the cutting edge angle exceeds 35 degrees, the main cutting edge is substantially shortened, resulting in reduction of the lifetime of the insert. More preferably, the cutting edge angle ranges from 10 to 30 degrees.

[0011] The main cutting edge preferably ranges from 3 to 7 mm in length. The reason why is that, e.g. in a case where the material to be cut, equivalent to carbon steel S50C is cut at a feed per one tooth (fz) of 1 to 1.2 mm/tooth, if the length is less than 3 mm, the insert is likely to be defected and thus the lifetime thereof is shortened, whereas if the length exceeds 7 mm, the cutting resistance is excessively increased. Therefore, it is preferable that radius of curvature R is increased and that the length is set to 3 to 7 mm.

[0012] Generally, it is recommended that the length of the main cutting edge is set to 20 to 60% of the diameter of the inscribed circle in the insert. Moreover, so long as the main cutting edge are rounded at both ends thereof even if it is shaped like a straight line, it has substantially the same characteristic. Therefore, if the main cutting edge is shaped like a straight line and then rounded in proper quantity at both end thereof, the insert is enabled to be formed at a low cost, although the lifetime is slightly degraded.

[0013] Moreover, in the indexable insert used for this tool, it is preferable that a line segment extending from an arc-center of the main cutting edge (arc portion) 7 to

the connecting point between the main cutting edge 7 and an inner peripheral cutting edge (straight portion) 8 intersects to the inner peripheral cutting edge 8 at an angle of less than 90 degrees (α in Figs. 2 and 4). This is because the angle exceeding 90 degrees makes it difficult to set the main cutting edge within the range from 3 to 35 degrees in cutting edge angle and arrange the inner peripheral cutting edge at a suitable angle when the insert is mounted to the holder.

Besides, the insert may be an indexable insert which is of a substantially rectangular and two-corner-used type, and shaped like a point-symmetry with respect to the center of the pin hole (See Fig. 2). Further, the insert may be an indexable insert which is of a substantially triangular and three-corner-used type, and has the straight portion 8 and the arc portion 7 (See Fig. 4).

[0014] The above and other objects, features, and advantages of the invention will more apparent from the following detailed description taken in conjunction with the accompanying drawings.

BRTFF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a partial sectional view of an indexable type rotary cutting tool 1 according to the present invention;

Fig. 2 is a front view of an indexable insert which is mounted to the tip portion of the indexable type rotary cutting tool 1 shown in Fig. 1;

Fig. 3 is a side view of the indexable insert;

Fig. 4 is a front view of another indexable insert suitable for use in the tool of the invention;

Fig. 5 is a front view of a cutter using an indexable insert of a conventional example;

Fig. 6 is a view useful in explaining the difference between the tool according to the embodiment of the present invention and that of the conventional example, both of which repeat cutting during contour line working;

Fig. 7 is a view useful in explaining a manner of carrying out contour line working by the embodiment of the invention; and

Fig. 8 is view useful in explaining the cutting results of the embodiment of the invention and the conventional example.

DETAILED DESCRIPTION OF THE RREPERRED EMBODIMENTS

[0016] Preferred embodiments according to the present invention will be described hereunder with reference to the accompanying drawings.

[0017] Fig. 1 shows a tool main body 1 to which an insert 3 is mounted, and Fig. 2 shows a substantially rectangular insert 3 used in an embodiment of the present invention. Fig. 3 is a side view of the insert 3 shown in Fig. 2.

[0018] As shown in Fig. 1, the rectangular insert 3 shown in Fig. 2 according to the first embodiment of the invention is fixed to a distal end portion 2 of the tool main body 1 shown in Fig. 1 by inserting a set screw 4 through a pin hole of the insert. Alternatively, clamping of the insert 3 with a wedge may provide the same performance as is the case of the fixing of the insert 3 with the set screw 4.

[0019] As shown in Fig. 1, the insert 3 of the first embodiment has a main cutting edge 7 and an outer peripheral cutting edge 9. The main cutting edge 7 is designed in an arcuate or substantially arcuate shape so that the cutting edge angle (κ) thereof is within the range from 3 to 35 degrees. The outer peripheral cutting edge 9 is designed in a straight, arcuate or substantially arcuate shape so as to be back-tapered with respect to the center axis of the tool.

[0020] The indexable insert 3 of this embodiment is also designed like a point-symmetry with respect to the center of the pin hole thereof so as to use two corners thereof. Each of two sides 9 which are symmetrical with respect to the center of the pin hole in the four sides forming the substantial rectangle is shaped like a straight line, an arc or a substantial arc. Each of the other sides comprises an arc potion (main cutting edge) 7 shaped like an arc or a substantially arc, and a straight portion 8 continuing from the arc portion. As shown in Fig. 2, a line segment extending from the center of the arc of the arc portion 7 to the connecting point between the arc portion 7 and the straight portion 8 intersects to the straight portion 8 at an angle (α) which is less than 90 degrees.

[0021] The length of the main cutting edge 7 is preferably set to 3 to 7 mm, however, the present invention is not limited to this value. Further, when the main cutting edge 7 is shaped like a straight line, it is rounded in proper quantity at both ends thereof.

[0022] Further, Fig. 4 shows a substantially triangular insert 6 used in a second embodiment of the present invention.

[0023] Each of the three sides forming the substantial triangle comprises an arc portion 7 shaped like an arc or a substantially arc, and a straight potion 8 continuing from the arc potion 8. In this embodiment, a line segment extending from the arc-center of the arc portion to the connecting point between the arc portion and the straight portion intersects to the straight portion at an angle (α) which is less than 90 degrees.

[0024] The above structure of the insert 6 of the second embodiment provides a three-corner-used and indexable insert.

[0025] Fig. 5 shows a radius cutter using a conventional button insert. Fig. 6 is a view useful in explaining the difference between the conventional button insert and the rectangular insert of the first embodiment of the invention.

[0026] Next, the comparison test was carried out under the condition that contour lines were engraved as indi-

cated by arrows in Fig. 7. A tool of 80 mmϕ was attached to a cutter arbor while the overhang length L over a gauge line was set to 270 mm so as to make it easy to induce the chattering-vibration. Further, the material was worked in the order of shoulder-cutting, groove-cutting, shoulder-cutting, ... so as to set the working condition so that the insert was easily defected in the cutting process of the groove. Further test conditions were given as follows: the material to be cut was made of S50C as is the case of a cutting test 1, the cutting speed V was set to 200 m/min (number of revolution N = 800 rpm), depth of cut Ad was set to 1.5.mm, width of cut Rd was set to 40 (shoulder-cutting) to 80 (groove-cutting), and the cutting style was set to a dry cutting style. The feed per one tooth (fz) was increased while observing the cut condition. That is, the feed per one tooth (fz) was increased in turn in the order of 0.25, 0.5, 0.75, 1.0 mm/tooth, while the cut condition was evaluated from the viewpoint of vibration. Moreover, these fz values will come to 1000, 2000, 3000, 4000 mm/min in terms of the table feed amount F.

[0027] The test results are shown in Fig. 8, in which a mark ◎ shows "good", a mark Δ shows "passable", a mark × shows "cutting-impossible". Fig. 8 shows that in the conventional example, the working is available at the first stage of the contour lines without problems, the chattering-vibration is increased at the second stage and the subsequent stages (the depth of cut Ad is not less than 3 mm (depth of cut per one stage 1.5 mm x 2 times) and the working is not available when the feed per one tooth is equal to 0.75 mm. The third stage had the same result as the second stage. On the other hand, in the embodiments of the present invention, the material was subjected to satisfactory working over all the region in which the feed per one tooth fz is 0.25 to 1.00 mm at the first stage, and also to satisfactory engraving-working through the second, the third, and the fourth stage also, without the chattering-vibration.

[0028] The reason why such a satisfactory result is obtained will be described with reference to the schematic view of Fig. 6.

[0029] With respect to the conventional button insert 5, as the depth of cut (Ad) is increased by 1.5 mm at one time, the length of the cutting edge contacting to the material to be cut is increased. In other words, in the conventional example, as the depth of cut Ad is increased like Ad x n-times (cutting number of times) during the contour line working, the length of the main cutting edge contacting to the material is increased.

[0030] On the contrary, in the embodiments of the invention, the length of the main cutting edge 7 is set to a value nearly equal to the depth of cut Ad for one time, which enables the main cutting edge to cut the material without changing its length at the second stage and the subsequent stages also. In other words, in the embodiment of the invention, attention is paid to the length of the main cutting edge which is set such that the chattering-vibration is not caused at the first stage, and this length of the main cutting edge is set. Therefore, even when the engraving working is carried out at any frequency, no chattering-vibration occurs, and thus a stable working can be performed.

[0031] Expressing numerically in concrete terms, so long as the machine horse power is allowed even if the cutter is not so big, when cutting the material of S50C on the condition that five teeth of 80 mmϕ are provided , the cutting speed V is 180 m/min (number of revolution N is equal to 720 rpm), the depth of cut Ad is set to 1.5 mm, the width of cut Rd is for groove-cutting, and the feed of one tooth fz is set to 1 mm/tooth, there could be provided a tool which has the capacities, such as the table feed amount F of 3600 mm/min and the maximum metal removal rate of 432 cc/min, and on the condition that the feed per one tooth is 2 mm/tooth, there could be provided a tool which has the capacities, such as the table feed amount F is 7200 mm/min and the maximum metal removal rate of 864 cc/min. Taking into consideration that such a cutting process that the metal removal rate exceeds 200 cc/min is conventionally called "heavy cutting (high efficient working)", the metal removal rate in the embodiments of the invention can exceeds two times of 200 cc/min, which shows the superiority of the embodiments of the invention to the conventional example.

[0032] According to the invention, the substantial length of the cutting edge during a cutting process is substantially constant, thereby resulting in a smooth facing and engraving, which provides a high efficient working. This results in enhancement of the efficiency of the contour line working.

Claims

1. An indexable type rotary cutting tool (1) having at least one indexable insert (3), said indexable insert (3) being designed in a substantially rectangular shape having a pin hole, each of two sides located at symmetrical positions out of four sides constituting said indexable insert (3) being linear, one of them serving as an outer peripheral cut-ting edge (9), each of the other two sides located at symmetrical positions comprising portion shaped like an arc or substantially shaped like an arc or shaped like a straight line rounded at both ends thereof, one of them serving as a main cutting edge (7),and a linear portion which coritinues from the main cutting edge (7) and serves as an inner peripheral cutting edge (8), **characterized in that** the outer peripheral cutting edge is back-tapered with respect to the center axis of the tool and said main cutting edge (7) is designed so as to range from 3 to 35 degrees in cutting edge angle (K) and have a length over which said main cutting edge (7) comes into contact with a work piece, the length being substantially unchanged even when an engraving working is repeated.

2. An indexable type rotary cutting tool (1) haying at

least one indexable insert (6), said indexable insert (6) being designed in a substantially triangular shape having a pin hole, each of three sides constituting said indexable insert (6) comprising a portion shaped like an arc or substantially shaped like an arc or shaped like a straight line rounded at both ends thereof, one of them serving as a main cutting edge (7) and a linear portion which continues from the main cutting edge (7) and serves as an inner peripheral cutting edge (8), **characterized in that** said main cutting edge (7) is designed so as to range from 3 to 35 degrees in cutting edge angle (K) and have a length over which said main cutting edge (7) comes into contact with a work piece, the length being substantially unchanged even when an engraving working is repeated.

3. The indexable type rotary cutting tool (1) according to claim 1 or 2, wherein the length of said main cutting edge (7) is set to 3 mm to 7 mm.

4. The indexable type rotary cutting tool (1) according to claim 1 or 2, wherein said main cutting edge (7) is shaped like an arc, and a line segment extending from an arc center of said arc portion to the connecting point between the main cutting edge (7) and the inner peripheral cutting edge (8) intersects to the inner peripheral cutting edge (8) at an angle (α) of less than 90 degrees.

5. The indexable type rotary cutting tool (1) according to claim 1 or 2, a part of said arc portion of said main cutting edge (7) is linear, and the connecting point between said main cutting edge (7) and said inner peripheral cutting edge (8) and the connecting point between said main cutting edge (7) and said outer peripheral cutting edge (9) are rounded.

Patentansprüche

1. Drehbares Wende-Schneidwerkzeug (1) mit mindestens einem Wende-Einsatz (3), der in im wesentlichen rechteckiger Form mit einem Stiftloch ausgebildet ist, wobei von den vier den Wende-Einsatz (3) bildenden Seiten jeweils zwei an symmetrischen Positionen angeordnete Seiten linear sind, von denen eine als äußere Umfangsschneidkante (9) dient, und die anderen beiden an symmetrischen Positionen angeordneten Seiten jeweils einen bogenartig oder im wesentlichen bogenartig oder als gerade Linie, deren beide Enden abgerundet sind, geformten Bereich, von denen einer als Hauptschneidkante (7) dient, und einen linearen Bereich, der von der Hauptschneidkante (7) ausgeht und als innere Umfangsschneidkante (8) dient, enthalten,
dadurch gekennzeichnet, daß die äußere Umfangsschneidkante gegenüber der Mittelachse des Werkzeugs eingeschrägt ist und die Hauptschneidkante (7) so ausgebildet ist, daß sie in einem Bereich von 3 bis 35° des Schneidkantenwinkels (K) liegt und eine Länge aufweist, über die sie in Kontakt mit einem Werkstück kommt und die auch bei wiederholter ausnehmender Bearbeitung im wesentlichen unverändert bleibt.

2. Drehendes Wende-Schneidwerkzeug (1) mit mindestens einem Wende-Einsatz (6), der in im wesentlichen dreieckiger Form mit einem Stiftloch ausgebildet ist, wobei die drei den Wendeeinsatz (6) bildenden Seiten jeweils einen bogenartig oder im wesentlichen bogenartig oder als gerade Linie, deren beide Enden abgerundet sind, geformten Bereich, von denen einer als Hauptschneidkante (7) dient, und einen linearen Bereich, der von der Hauptschneidkante (7) ausgeht und als innere Umfangsschneidkante (8) dient, enthalten,
dadurch gekennzeichnet, daß die Hauptschneidkante (7) so ausgebildet ist, daß sie in einem Bereich von 3 bis 35° des Schneidkantenwinkels (K) liegt und eine Länge aufweist, über die sie in Kontakt mit einem Werkstück kommt und die auch bei wiederholter ausnehmender Bearbeitung im wesentlichen unverändert bleibt.

3. Werkzeug (1) nach Anspruch 1 oder 2, wobei die Länge der Hauptschneidkante auf 3 mm bis 7 mm festgelegt ist.

4. Werkzeug (1) nach Anspruch 1 oder 2, wobei die Hauptschneidkante (7) bogenförmig ist und ein Liniensegment, das von der Bogenmitte des Bogenbereichs zum Verbindungspunkt zwischen der Hauptschneidkante (7) und der inneren Umfangsschneidkante (8) verläuft, die innere Umfangsschneidkante (8) unter einem Winkel (α) von weniger als 90° schneidet.

5. Werkzeug (1) nach Anspruch 1 oder 2, wobei ein Teil des Bogenbereichs der Hauptschneidkante (7) linear ist und der Verbindungspunkt zwischen der Hauptschneidkante (7) und der inneren Umfangsschneidkante (8) sowie der Verbindungspunkt zwischen der Hauptschneidkante (7) und der äußeren Umfangsschneidkante (9) abgerundet sind.

Revendications

1. Outil de coupe rotatif du type indexable (1) comprenant au moins un insert indexable (3), ledit insert indexable (3) étant configuré sous une forme sensiblement rectangulaire comportant un trou de fixation, chacun parmi deux côtés situés en des positions symétriques parmi quatre côtés constituant ledit insert indexable (3) étant linéaire, l'un d'entre eux

servant de bord de coupe périphérique extérieur (9), chacun des deux autres côtés situés en des positions symétriques comprenant une partie conformée sous la forme d'un arc ou sensiblement conformée sous la forme d'un arc ou conformée sous la forme d'une ligne droite arrondie aux deux extrémités de celle-ci, l'une d'entre elles servant de bord de coupe principal (7), et une partie linéaire qui se poursuit à partir du bord de coupe principal (7) et sert de bord de coupe périphérique intérieur (8), **caractérisé en ce que** le bord de coupe périphérique extérieur est incliné vers l'arrière par rapport à l'axe central de l'outil et **en ce que** le bord de coupe principal (7) est configuré de façon à avoir un angle de bord de coupe (K) situé entre 3 et 35 degrés, et à avoir une longueur sur laquelle ledit bord de coupe principal (7) vient en contact avec une pièce à usiner, la longueur étant sensiblement inchangée même lorsqu'un travail de gravure est répété.

2. Outil de coupe rotatif du type indexable (1) comportant au moins un insert indexable (6), ledit insert indexable (6) étant configuré sous une forme sensiblement triangulaire comportant un trou de fixation, chacun parmi trois côtés constituant ledit insert indexable (6) comprenant une partie conformée sous la forme d'un arc ou sensiblement conformée sous la forme d'un arc ou conformée sous la forme d'une ligne droite arrondie aux deux extrémités de celle-ci, l'une d'entre elles servant de bord de coupe principal (7), et une partie linéaire qui se poursuit à partir du bord de coupe principal (7) et sert de bord de coupe périphérique intérieur (8), **caractérisé en ce que** ledit bord de coupe principal (7) est conçu de façon à avoir un angle de bord de coupe (K) situé entre 3 et 35 degrés et à avoir une longueur sur laquelle ledit bord de coupe principal (7) vient en contact avec une pièce à usiner, la longueur étant sensiblement inchangée même lorsqu'un travail de gravure est répété.

3. Outil de coupe rotatif du type indexable (1) selon la revendication 1 ou 2, dans lequel la longueur dudit bord de coupe principal (7) est établie entre 3 mm et 7 mm.

4. Outil de coupe rotatif du type indexable (1) selon la revendication 1 ou 2, dans lequel ledit bord de coupe principal (7) est conformé sous la forme d'un arc, et un segment de ligne s'étendant d'un centre d'arc de ladite partie d'arc au point de connexion entre le bord de coupe principal (7) et le bord de coupe périphérique intérieur (8) coupe le bord de coupe périphérique intérieur (8) selon un angle (α) inférieur à 90 degrés.

5. Outil de coupe rotatif du type indexable (1) selon la revendication 1 ou 2, une partie de ladite partie d'arc dudit bord de coupe principal (7) étant linéaire, et le point de connexion entre ledit bord de coupe principal (7) et ledit bord de coupe périphérique intérieur (8) et le point de connexion entre ledit bord de coupe principal (7) et ledit bord de coupe périphérique extérieur (9) étant arrondis.

FIG. 1

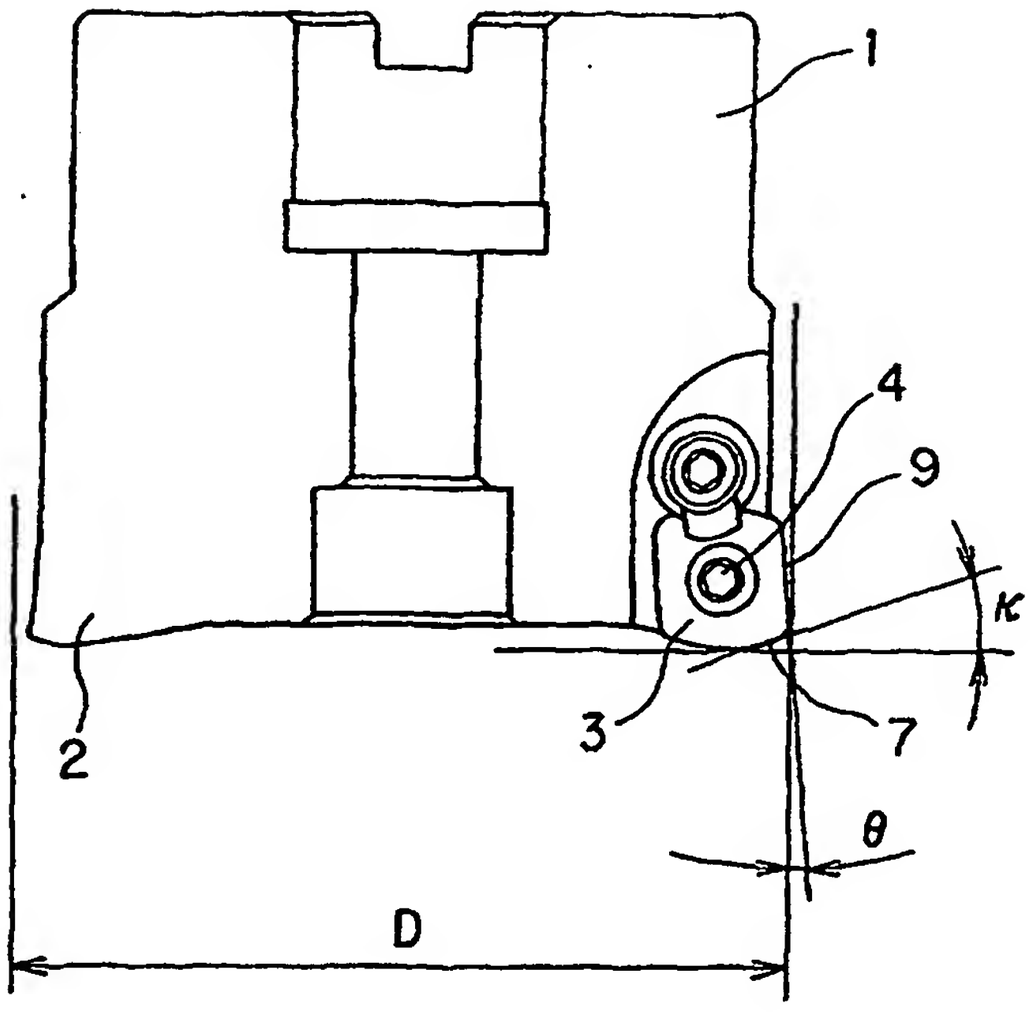

FIG. 2

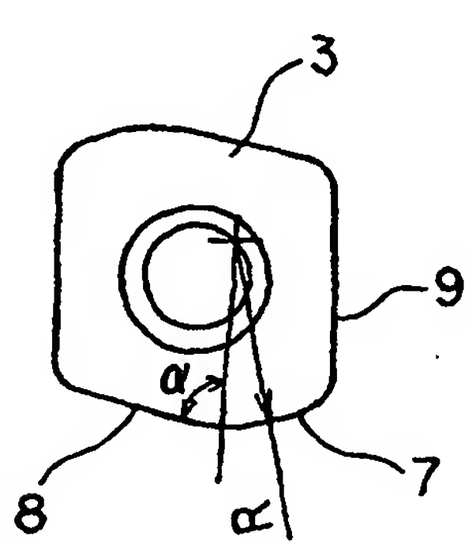

FIG. 3

FIG. 4

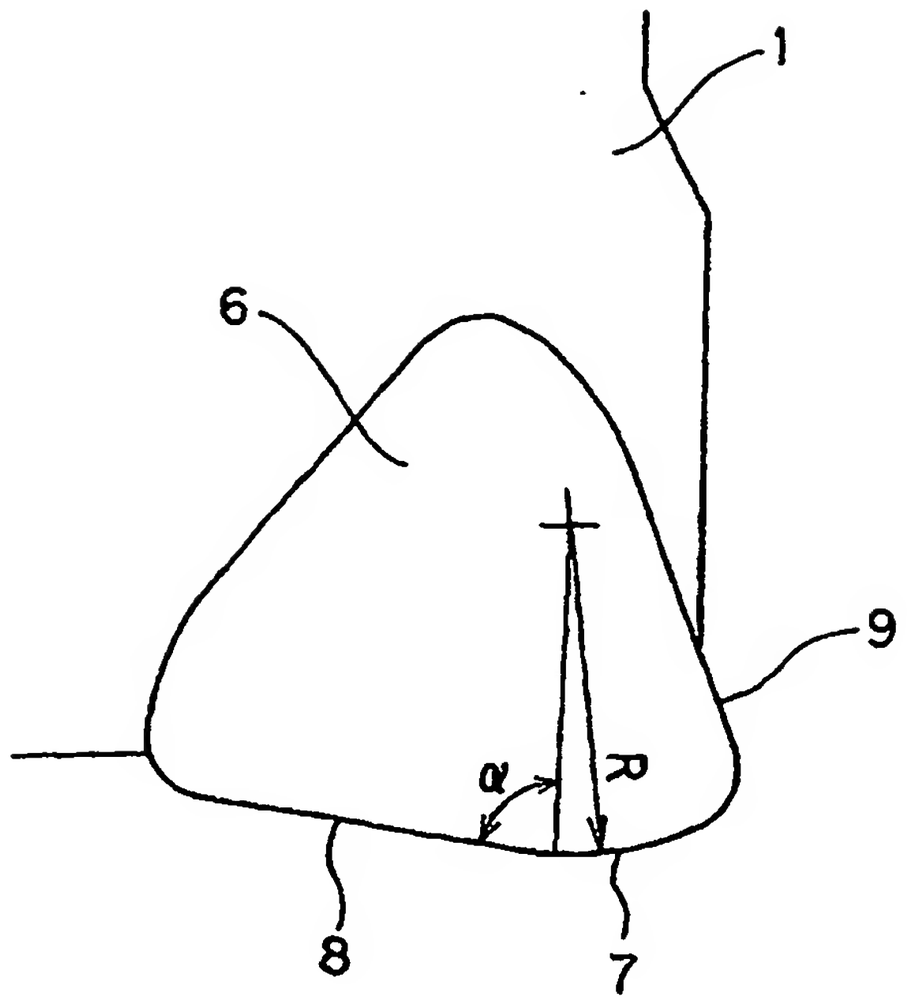

FIG. 5

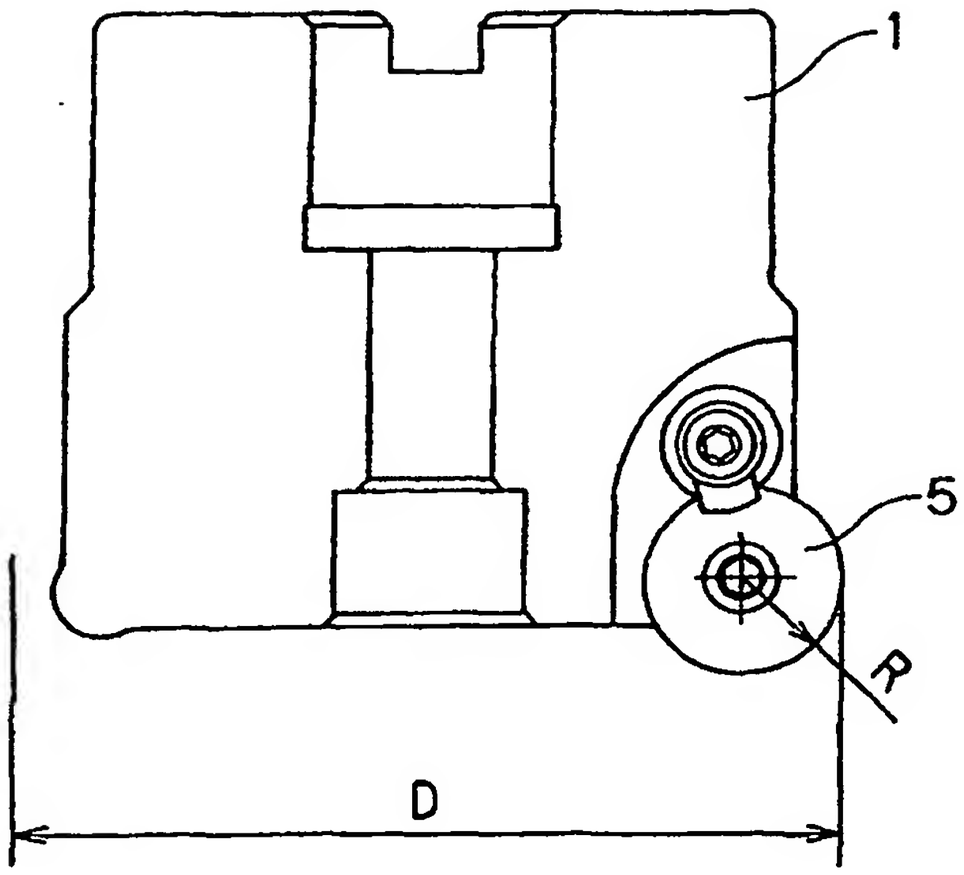

FIG. 6

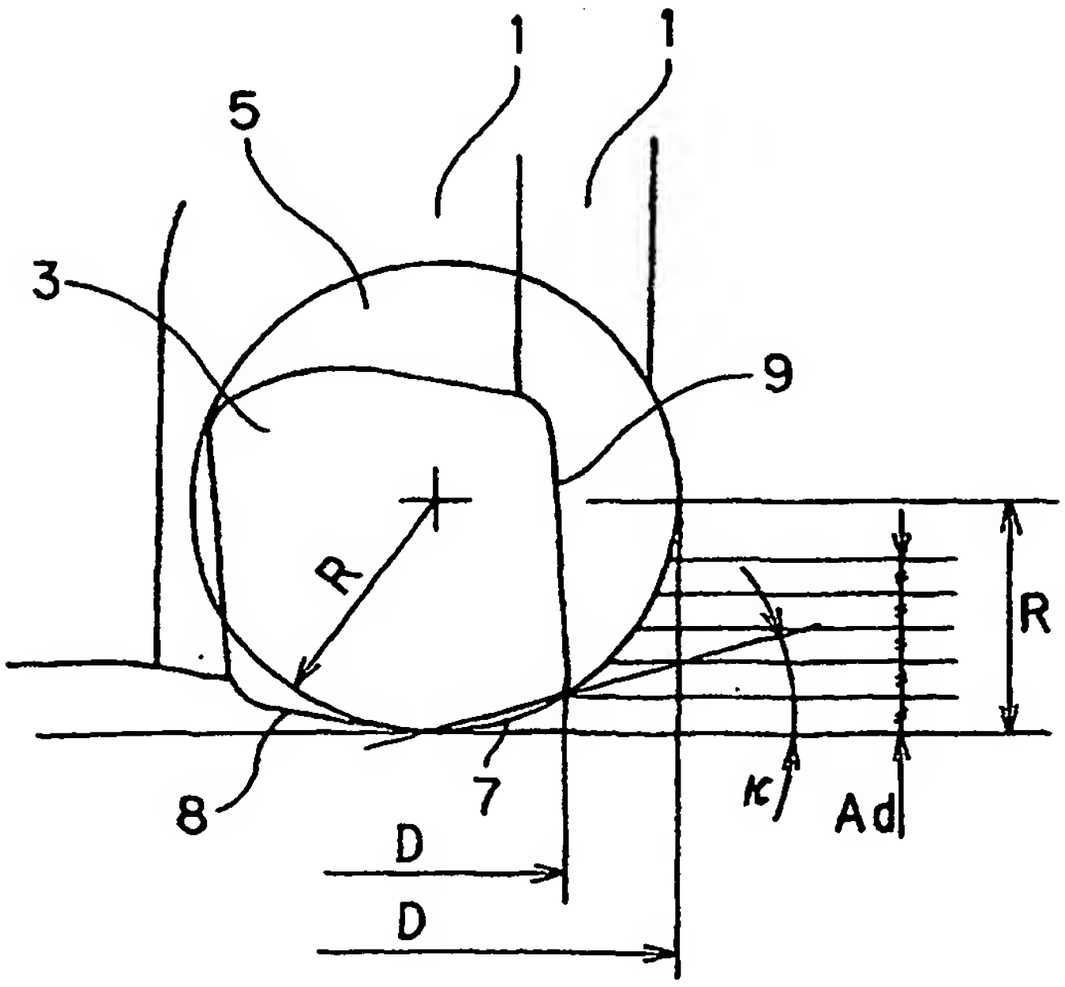

FIG. 7

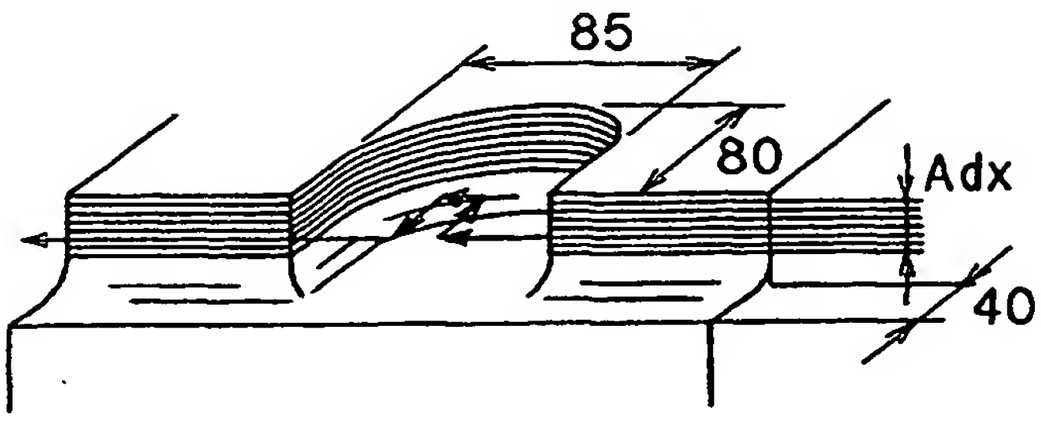

FIG. 8

	CUTTING NUMBER OF TIMES (STAGE)	1000 2000 3000 4000 F (mm/min) 0.25 0.5 0.75 1.0 fz (min/tooth)
EMBODIMENT	FIRST STAGE	GOOD
	SECOND STAGE	GOOD
	THIRD STAGE	GOOD
PRIOR ART	FIRST STAGE	GOOD
	SECOND STAGE	LARGE CHATTERING-VIBRATION
	THIRD STAGE	LARGE CHATTERING-VIBRATION